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An identification key of the most important German freshwater teleost fishes by means of their eggs.

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I. Introduction.

The fetal and larval development of many freshwater fish is already relatively well covered (KASANSKY, 1925, 1928; SCHNAKENBECK, 1936, 1941; OPPENHEIMER, 1937; BALINSKY, 1948; WINN & MILLER, 1954; DZIEKONSKA, 1956; BALON, 1956, 1958a, b, 1959; BRACKEN & KENNEDY, 1967). Compared with this literature, coverage of the morphology of fish-species' eggs is very sparce, (BRACKEN & KENNEDY, 1967; KLAUSEWITZ, 1974). The number of fish species examined is very limited being 13 species in the index by BRACKEN & KENNEDY (1967) and 11 species in the index by KLAUSEWITZ, (1974). For this reason we have attempted to prepare a key on fish eggs which covers the bulk of native teleost fish. The results of BRACKEN & KENNEDY (1967) and KLAUSEWITZ (1974) are considered.

II. Materials & Methods.

Requirements for the study of fish include, on the one hand, fish-hooks and sinking nets as well as an electric fish trap, and on the other hand, an instititution available for supplying support. The electric fish trap is of especial value in capturing species which are otherwise difficult to approach.

The fish eggs were obtained in different ways. The 3-pointed stickleback and the stone loach were spawned in the laboratory. Crude identification of the following species was carried out in early summer in the field: Rhodeus sericeus amarus, Gymnocephalus cernua, Leucaspius delineatus, Cottus gobio, Rutilus rutilus, Leuciscus leuciscus, L. cephalus, Alburnus alburnus, Scardinius erythrophthalmus & Tinca tinca. The other eggs were secured from Skimmer mature spawn. Species found in the field could not all be immediately classified unambiguously of course. Therefore, the eggs were put in the hatching aquarium and young fish were grown to a reasonable size. Only then was a real determination of the species feasible. These eggs included the following Gymnocephalus cernua, Rutilus rutilus, Leuciscus leuciscus, L. cephalus, Alburnus alburnus, Scardinius erythrophthalmus and Tinca tinca. The eggs were first investigated in the live state and then in a fixed condition, both macroscopically and microscopically.

The eggs of the following species were fixed and cut for histological and ultrahistological examination of the egg membrane and micropyle: Noemacheilus barbatulus, Gobio gobio, Leuciscus cephalus, Phoxinus phoxinus, Tinca tinca, Gasterosteus aculeatus, Esox lucius, Coregonus wartmanni, Coregonus macrophthalmus. They were fixed in 4% formalin 2.5% glutaraldehyde, BOUIN, CARNAY *sublimate glacial acetic acid, (light microscopy) and SJÖSTRAND 1956 (Electronmicroscopy). Samples were embedded in paraffin wax (light microscopy) and Vestopal (Electronmicroscopy). Cutting was done on a Leitz-Microtome (5-10 µm) and a Reichert-Ultramicrotome OM U2 (semi-thin sections, 0.5 - 1 µm). Histological sections were stained with hemalum after P. Mayer, hematoxylin after Delafield and Azure-II-eosin after Nocht-Maximov; the semi-thin sections were stained with 0.5% Toluidine-blue solution. Ultrathin sections require careful preparation with lead citrate after Reynolds (1963) contrast examination under a EM 9 Zeiss at about 60 KV.

III Problems of Categorization

The authors are conscious of the fact that the preparation of a key for identification of fish species by their eggs, holds many concealed problems. Sometimes the differences between the eggs of different species are very insignificant but in other cases the differences can vary within considerably larger limits. In addition to this, we have only been able to consider material from about half of the Teleost species which occur in Germany.

One of the main reasons for this is the difficulty in getting a supply of material. Populations of common fish species are relatively easy to maintain in a breeder. In comparison, to maintain a good supply of material from insignificant, unusual or unknown species is difficult or impossible. This pertains to, among other things Donau perch and whitefish species.

In spite of these difficulties, an identification key for the available species has been devised and should provide a certain amount of background for the field. In the key, data considered were derived from eggs in the embryonal phase; the fetal period not yet being distinctive. (Classification of fetal development see BALON, 1960).

The eggs of the Salmonids and Coregonids were a particular problem. The eggs of the Salmonids are, for the most part, easy to discriminate from other fish species but within the family one meets various problems in

* Translators note: (mercuric chloride)

identification. Variations in the colour occur but are subject to many factors. The colour of egg is, as a rule, not very useful as a guide to identification. One exception was in our investigation of Salmo gairdneri eggs. Upon examination of material from different districts of Germany and adjacent foreign countries, this egg showed a rose colour.

In general, the egg diameter is an indicative criteria in Salmonids. In the case of individual species however, egg diameter is not an absolutely reliable identification as overlap is common. The investigation by SCHNAKENBECK, 1941 shows that the egg diameter varies considerably in fish of different sizes and ages. These variations were apparent in our investigation as well. However, they generally fall in a position within the indicated limits of the key.

Important distinctions exist in the egg size of the Coregonids. The limits lie between 1.8 mm and 3.6 mm. Individual sizes of different groups gradually merge into each other but a classification by egg size at the extremes is very possible. This is shown in the Coregonus nasus group which has the largest egg in the Coregonid family and is shown in the key. Their size rarely overlaps with the eggs of another group in the Coregonid. Coregonid eggs with small diameters may belong to different groups and the key is not applicable to these cases.

IV Terminology of the ovum and egg membrane.

The coverings in which the majority of fish eggs are enclosed are typical. At this time, it is necessary to make some observations on the use of terminology for the 'envelopes'. During the 'classical' periods of light microscopy, there originated an abundance of designations which correspond to specific formations of the egg cover. Rationalization of the many terms covering the envelope is difficult. The electronmicroscope terms used in the report of GÖTTING, 1967 on marine Teleosts and in the report of RIEHLE, (1978) on freshwater Teleosts have been adapted. Thus, fish eggs are enclosed in the pellucida zone. Many of these can be subdivided into the pellucida zone proper and the radial cortex. The radial cortex is the light covering of ovum and eggs. It exists in some fish (e.g. Noemacheilus barbatulus, Gobio gobio) as the external radial cortex, (Synonyms found in other light and electronmicroscopy literature: villous layer, villous egg membrane, external radial zone) and the internal radial cortex (Synonyms: Radial zone, internal radial zone, radially striated cortical layer, radially striated outer layer. Fig. 1). (In the identification key) the papillae are at the cone of the external radial cortex and serve to firmly attach the egg to the substratum.

V The micropyle as a determining characteristic.

In the key, the micropyle has not been used extensively as a determining characteristic, although we think it is accurate enough for use in this way. At the moment, investigation of micropyle is slow and about 20 fish species can be identified. In each of these species, the micropyle has a characteristic standard and appearance.

As a rough classification, micropyle may be divided into 3 distinct component types, of which Type 1 and Type 3 are of sole interest in this paper. Type 1 contains micropyles with deep depressions and short micropyle canals (Fig. 2a). To this group belong, among others, whitefish and (Schmerle). Type 3 contains micropyle without depressions but with canals (Fig 2b). The disadvantage to using the micropyle as a determining characteristic arises from the fact that eggs are not considered in the live state but must be fixed and cut for identification.

VI KEY

1 Egg ovoid; longest diameter 3 mm, transverse diameter 2 mm; eggs are oviposited in the gill chamber of freshwater mussels. The egg gets into the branchia of mussels and develops there.
Rhodeus sericeus amarus BLOCH, 1782 Bitterling

2 Eggs spherical 3

3 Egg diameter 6 mm or more; egg diameter 6-7 mm; egg yellowish, sinks and does not cling; distinctly viable micropyle; eggs deposited Sept.-Jan.
Salmo salar LINNAEUS, 1758 - Lachs. (Salmon)

4 Diameter under 6 mm 5

5 Diameter over 4 mm 7

6 Diameter under 4 mm 11

7 Egg colour yellowish 9

8 Egg colour rose; diameter 4.5 - 5.8 mm; distinctly visible micropyle; eggs released March to April
Salmo gairdneri RICHARDSON, 1836 - Regenbogenforelle, (rainbow trout)

9 Eggs released Jan - March; diameter 4.5 - 5.5 mm; distinctly visible micropyle.
Salmo trutta LINNAEUS., 1758 - Meerforelle (trout)
Salmo trutta f. fario LINNAEUS, 1758 - Bachforelle (brown trout)
Salmo trutta f. lacustris LINNAEUS, 1758 -Seeforelle (lake trout)

10 Eggs released March to May; diameter 5 mm; distinctly visible micropyle; in the Donau and its tributaries

Hucho hucho (LINNAEUS, 1758) - Huchen

11 Egg diameter over 3mm 13

12 Egg diameter under 3 mm 19

13 Eggs have 3 coverings: diameter 3 mm; eggs light yellow and sink, cling to reeds and in canals; released May - July.

Silurus glanis LINNAEUS, 1758 - Wels, Waller

14 Eggs have only 1 casing 15

15 Eggs honey to amber yellow; diameter 3 - 3.5 mm; eggs sink and do not cling; distinctly visible micropyle; spawn release Oct. to Dec.

Group Coregonus nasus (PALLAS, 1776)

Synonyms: Coregonus fera JURINE, 1825 - Sandfelchen

Coregonus holsatus THIENEMANN, 1916. Grosse Maräne (Great Marane)

The eggs of other Coregonus species are usually smaller (diameter 1.8 - 2.5 mm) waxy-yellow and sometimes cling. All have a disthctly visible micropyle, as yet there are no additional differences.

16 Eggs brownish to yellowish 17

17 Eggs brownish; deposited March - June; diameter 3 - 4 mm, eggs sink and do not cling.

Thymallus thymallus (LINNAEUS, 1758)-Grayling

18 Eggs yellowish to faint rose; deposited Nov. to Jan. (March); diameter 3.5 - 4 mm; eggs sink and do not cling; distinctly visible micropyle.

Salvelinus alpinus (LINNAEUS, 1758) - Wandersaibling (char)

Salvelinus fontinalis (MITCHILL, 1815) - Bachsaibling (brook char)

19 Diameter 1 mm and more 21

20 Egg diameter under 1 mm 61

21 Eggs have a gelatinous envelope; diameter 1.8 - 2.5 mm; eggs are colourless to pale yellow; elastic and clear; large oil globules are found in the centre of the yolk. Eggs are in strings situated on waterplants, wood and stones; deposited April to May (Fig. 3a and b).

Perca fluviatilis LINNAEUS 1758 - Flussbarsch - (river perch)

22 Eggs without gelatinous envelope 23

23 One or several small oil globules are present 25

24 No small oil droplets present 32

25 One oil globule present 27

26 Several small oil droplets present 29

27 Diameter 1.5 mm; eggs cling and sink; eggs were released singly; deposited April to May. (Fig. 4a)
Stizostedion lucioperca LINNAEUS, 1758 - Zander (pike perch)

28 Diameter 1 - 1.2 mm; eggs do not cling, found on gravel; deposited Dec to March.
Lota lota (LINNAEUS, 1758) - Quappe (burbot), Rutte, Trüsche.

29 Diameter 2.5 mm; eggs honey to amber yellow; many small oil droplets in a series of small groups; eggs in living and dead plants in shallow water; eggs deposited Feb - April (Fig 5a & b)
Esox lucius LINNAEUS, 1758 - Hecht (pike)

30 Egg diameter 1.5 - 1.7 mm; tend to have at least 12 medium size oil droplets, which dissolve (coalesce) during the incubation period. Eggs laid in nests made of plant material and protected by the male. Eggs are deposited Feb - Aug (Fig 4b).
Gasterosteus aculeatus LINNAEUS, 1758 - Dreistachlinger Stichling (3 spined stickleback)

31 Egg diameter 1 mm; there are a series of oil droplets in the eggs; eggs are found in dense plant nests on the ground, the nest is protected by the male; eggs are deposited April to Aug.
Pungitius pungitius (LINNAEUS, 1788) - 9 spined stickleback

32 Egg masses in loops or spirals are found attached to reed stalks and the like; diameter 1 mm; the male guards the eggs until the hatching of the larvae; deposited May - July (Fig. 6a)
Leucaspius delineatus (HECKEL, 1843) - Moderlieschen

33 Eggs not ring shaped or spiral attached to reedstalks 34

34 Eggs are attached to the underside of stones, in clumps in cavities under the stones; diameter 2 - 2.5 mm; colour reddish-yellow; eggs guarded by the male until hatching. Deposited March - May
Cottus gobio LINNAEUS, 1758 - Groppe, Kaulkopf (bullhead)

35 Eggs not in the underside cavities of stones attached in clumps 36

36 Eggs opaque 38

37 Eggs clear or translucent 46

38 Eggs moderately opaque 40

39 Eggs entirely opaque 44

40 Egg surface is densly covered with small sticky papillae; diameter 1.9 - 2.1 mm; eggs greenish white to greyish white; yolk is yellowish. Eggs were attached to water plants, deposited May to June.
Rutilus rutilus (LINNAEUS 1758) - Rotauge, Plötze (roach)

41 Egg surface without papillae 42

42 Egg diameter 2 - 2.5 mm. Egg greenish white; they were clear during the incubation period; scattered among stones in flowing waters. Deposited Feb.-April.

Leuciscus leuciscus (LINNAEUS, 1758) - Hasel (Dace)

43 Diameter 1.5 - 1.8 mm; eggs greyish-white, yolk greyish yellow; in running water among stones and gravel; deposited May - June (Fig. 6b & c)

Phoxinus phoxinus (LINNAEUS, 1758) - Elritze (minnow)

44 Diameter 1.3 - 1.6 mm; colour grey; egg surface covered with long papillae; eggs found in running water attached to stones, waterplants and matted roots. Deposited May - June (Fig. 7)

Gobio gobio (LINNAEUS, 1758) - Grundling (gudgeon)

45 Egg diameter 1 - 1.2 mm; egg colour greenish to white; surface not covered with long papillae; eggs found in flowing water on rocks, water plants, gravel and sand. Deposited May - June (Fig. 8a & b)

Noemacheilus barbatulus (LINNAEUS, 1758) - Schmerle (stone loach)

46 Eggs translucent 48

47 Eggs clear 49

48 Egg diameter 1.6 - 2.0 mm; yolk yellow to orange; among water plants in shallow water. Deposited May - June.

Abramis brama (LINNAEUS, 1758) - Branchsen, Blei (bream)

49 Eggs individual, most attached to the substrate 51

50 Eggs in small clumps or balls 52

51 Egg diameter 1.4 - 1.8 mm; eggs generally colourless or yellowish to brown; attached to dense water plants under the surface and some on the bottoms. Deposited May - Aug.

Cyprinus carpio LINNEAUS, 1758 - Karpfen (carp)

52 Egg surface has papillae 54

53 Egg surface without papillae 56

54 Egg diameter 1.5mm; colour yellow; surface has short, not dense standing papillae; Eggs are attached in dence clumps under the water surface on living and dead plants. Deposited May to June.

Alburnus alburnus (LINNAEUS, 1758) - Ukelei (Bleak)

55 Egg diameter 2mm ; colour orange-yellow, egg surface covered with a few papillae; in flowing water attached to rocks and gravel. Deposited May to July. (Fig. 9a)

Leuciscus cephalus (LINNAEUS, 1758) - Döbel (Chubb)

56 Eggs without colour 58

57 Eggs yellowsih or green 59

58 Egg diameter 1.4 - 1.8 mm; Eggs colourless to pale yellow; eggs in standing water attached to waterplants by their sticky surface. Deposited May - July.

Scardinius erythrophthalmus (LINNAEUS, 1758) - Rotfeder (rudd)

59 Diameter 1.5 to 1.7 mm; eggs citron yellow to orange-colored, clear; spawn is found in calm eutrophic streams on water plants. Deposited May - July.

Carassius carassius (LINNAEUS, 1758) -Karausche (Crucian carp)

60 Egg diameter 1 - 1.4 mm; eggs greenish to pale yellow; on waterplants in shallow calm water. Deposited May - Aug. (Fig. 9b)

Tinca tinca (LINNAEUS, 1758) - Schleie (Tench)

61 2 egg membranes; diameter 0.6. - 0.9 mm; colour yellowish; the outside membrane allows the egg to stick fast to stones and plants and then bursts and slips down the egg. The outer membrane forms a base in the white species from which the egg is suspended. During the progressive development the outer membrane is lost on the ground. The egg is then suspended free in the water by a small attachment. Deposited Feb. - May (Fig. 10a & b).

Osmerus eperlanus (LINNAEUS, 1758) - Stint (Smelt)

62 Eggs have a distinct membrane; diameter 0.5 - 0.9 mm, rarely 1mm; colour yellowish-white; eggs attached to stones, seldom on water plants. Deposited March - May.

Gymnocephalus cernua (LINNAEUS, 1758)-Kaulbarsch (ruffe)

Explanation of the numbers employed in the figure legends.

1 internal radial cortex

2 external radial cortex

3 perivitellinraum

4 gelatinous envelope

5 micropyle

6 micropyle canal

7 oil droplets

8 yolk

9 papillae of external radial cortex.

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Figure Legends.

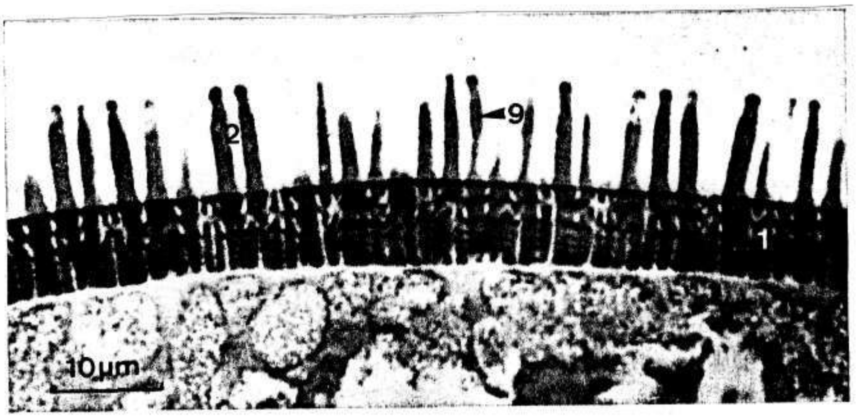

Fig. 1. The egg envelope of Gobio gobio (Semithin slice, 0.5 µm thick, Toluidine blue). The radial cortex is made up of the internal radial cortex and the external radial cortex.

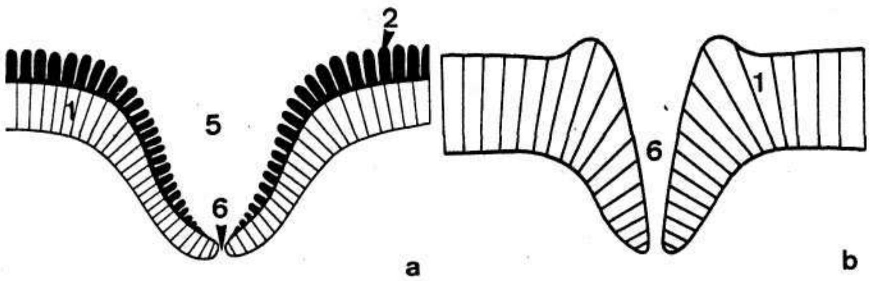

Fig. 2. Schematic representation of micropyle types,
a) Micropyle has deep depressions and short canals (Type 1)
b) Micropyle has only canals, not depressions (Type 3).
The Scale of the two micropylen is not identical.

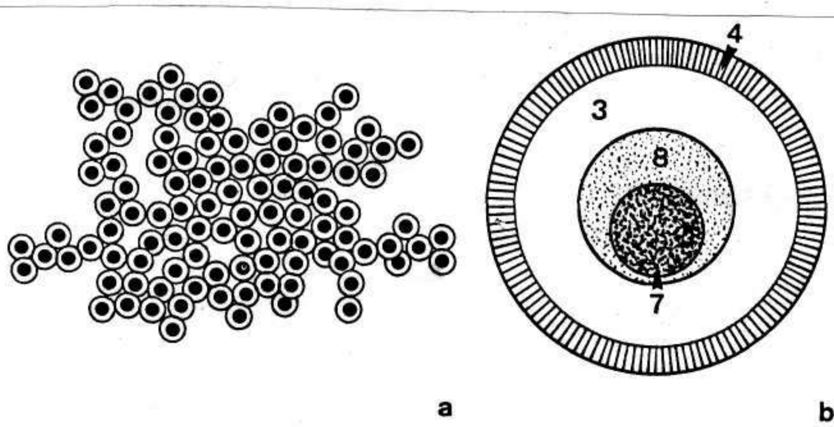

Fig. 3. a) Part of a string of perch eggs.
b) Diagram of the egg of Perca fluviatilis.

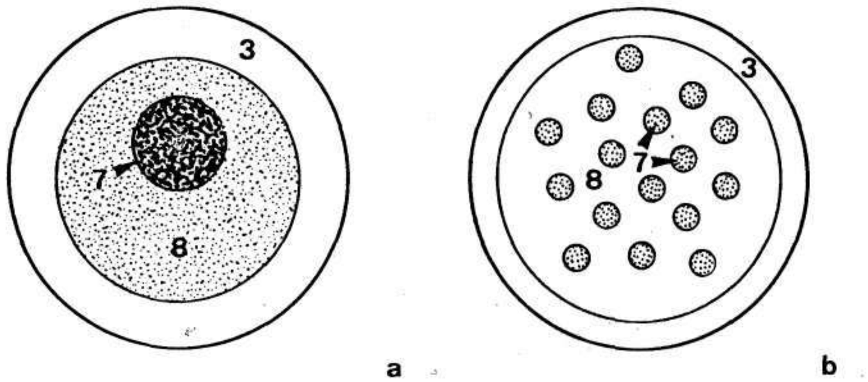

Fig. 4 a) Diagram of the egg of <u>Stizostedion</u> with a large oil droplet.
b) Diagram of the egg of <u>Gasterosteus aculeatus</u> with at least 12 small oil droplets.

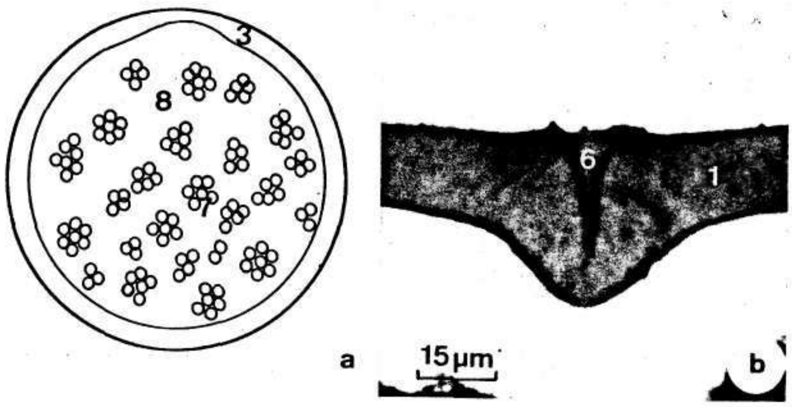

Fig. 5 a) Diagram of the egg of <u>Esox lucius</u>. Many oil droplets have settled in the small depression.
b) Micropyle of a Perch egg (Section thickness, 7 µm Hemalum)

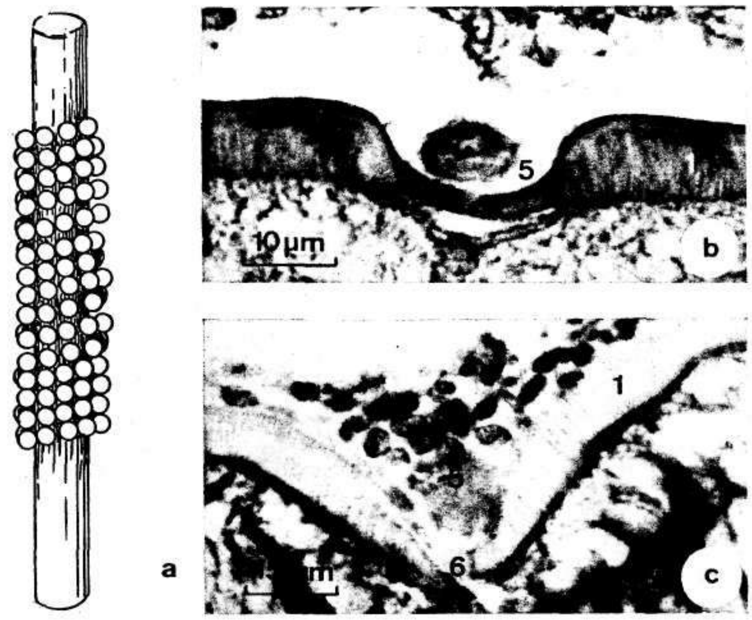

Fig. 6 a) Looped strings of Leucaspius delineatus on a reedstem.
b) Micropyle of young Phoxinus oocyte. (Section thickness 7 µm, hemalum).
c) Differentiated micropyle of Phoxinus phoxinus, (Section thickness 7 µm. Delafield).

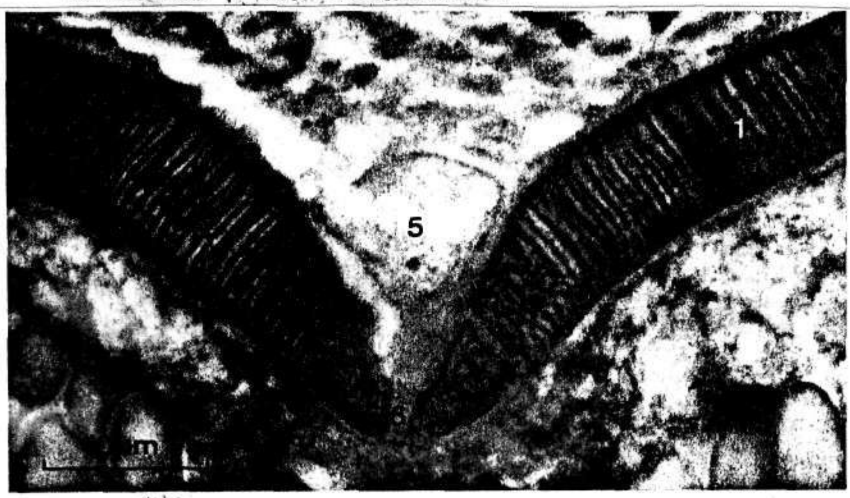

Fig. 7. Micropyle of Gobio gobio (Section 7 µm thick, Delafield).

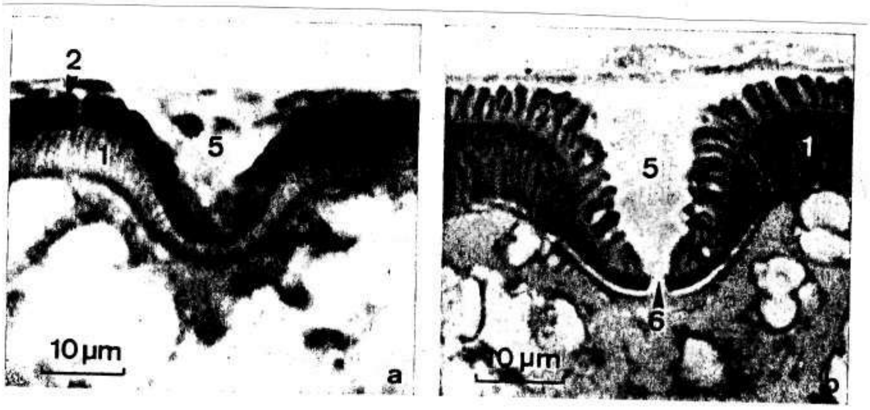

Fig. 8. Micropylen of Noemacheilus barbatulus.
a) Histological section (thickness 7 µm, Delafield)
b) Semi-thin section (thickness 0.5 µm, Toluidine blue).

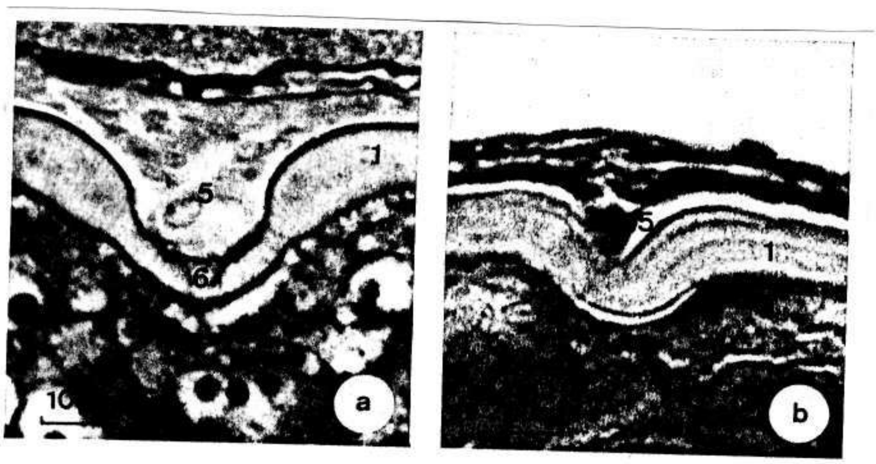

Fig. 9. a) Micropyle of Leuciscus cephalis (Section thickness 7 µm, Delafield).
b) Micropyle of Tinca tinca (Section thickness 10 µm, Hemalum)

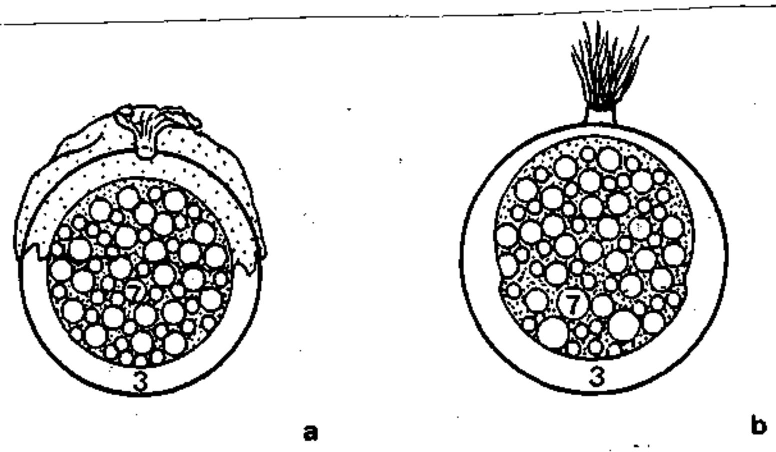

Fig. 10. Eggs of Osmerus eperlanus (diagramatic)
a) The outer egg casing begins to loosen
b) The outer casing is dissolved. The egg hangs by the casing (modified from EHRENBAUM).

Notice

Please note that these translations were produced to assist the scientific staff of the FBA (Freshwater Biological Association) in their research. These translations were done by scientific staff with relevant language skills and not by professional translators.